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THE STRATIGRAPHY OF THE CALIFORNIA COAST RANGES.

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INTRODUCTION.

In a recent publication the writer presented a résumé of the present state of knowledge of the geology of the California Coast Ranges.¹ It is intended to devote the present article partly to a more detailed statement of views expressed in that paper on the relation of the Miocene, Upper and Lower Cretaceous to each other, which could not be fully discussed for lack of space, and partly to the presentation of additional evidence in support of the writer's published views concerning the existence of a pre-Cretaceous (pre-Knoxville) series of rocks in the Coast Ranges. Most of the observations on which the opinions presented are based were made during the summers of 1891-2-3. Valuable additions were made the past fall, when in company with Mr. F. M. Anderson, a student in Stanford University, a three weeks' trip was made through the Santa Lucia Mountains in Monterey and San Luis Obispo counties.

¹ Bull. Geol. Soc. Am., Vol. VI., 71-102.

CRYSTALLINE BASEMENT COMPLEX.

Considerable areas of granite, crystalline schists, and limestone appear at many points in the Coast Ranges between Point Reyes and Ventura county. No information has yet been gained of the age of any portion of this basement complex, beyond the fact that it underlies unconformably the most ancient uncrystalline rocks which are probably not older than the Jurassic. It would appear that the granite cannot be correlated with that which was irrupted at the close of the Jurassic in the Sierra region. It seems highly probable, from our present knowledge, that a long period of erosion, during which these crystalline rocks were much more prominently exposed than at present, ensued between the upheaval and metamorphism of the schists and limestones, and the deposition of the lowest uncrystalline strata.

GOLDEN GATE SERIES.

Definition.—Between the lowest recognized Cretaceous and the basement complex is a series of rocks separated from both by nonconformities, and everywhere characterized by rather peculiar lithologic features. For this collection of strata, consisting chiefly of jasper, sandstone, shale, and slate, typically developed about the entrance to San Francisco Bay, the designation Golden Gate series is proposed. According to our present knowledge these rocks form a conformable series of strata with a remarkable similarity of character through their whole extent. The scanty fauna thus far known indicates that it does not embrace a great range of geological time, although its thickness is very considerable. The series has been recognized by the writer from central Santa Barbara county northwestward through the Coast Ranges to the Klamath Mountains. On the western slope of these mountains it has been traced to the Oregon line, and it undoubtedly extends farther. Until recently the series has been considered, by all geologists who have published results of work in the Coast Ranges, not older than the Knoxville, of which it has often been thought to be a metamorphosed portion. In 1892 the writer first advanced the view that these rocks were

not a portion of the Knoxville,¹ but that they underlaid it unconformably. Since then in other publications² additional evidences have been given of the geological independence of this series, of its distinct lithological character, and of its extent in the Coast Ranges. To the writer the evidences supporting this view seem to be conclusive. Nevertheless, the old view that these rocks constituted a metamorphosed portion of the Knoxville has been accepted so long, and has become so current in geological literature, that the new one has been looked upon with more or less doubt. The writer ventures to assert, however, that if the geology of the Coast Ranges had never been touched until today, the confounding of the Knoxville with the older series beneath never would have occurred. In the light of these conditions it has seemed best to continue to put on record all observations which would aid in bringing out a full recognition of the important fact that there is an uncrystalline series of rocks in the Coast Ranges beneath the Knoxville. The importance of the correct classification will be understood when it is stated that the strata included in the Golden Gate series extend for a distance of 500 miles through California, and for an unknown distance in Oregon. The recent field work in Monterey and San Luis Obispo counties has been so fruitful in positive results that the existence of a pre-Knoxville series of uncrystalline strata must be considered proved.

Lithologic character.—One of the distinct features of this series of rocks is its peculiar and comparatively uniform lithologic character. In general it is so different from that of any of the younger formations that it can be used as a criterion of distinction by one familiar with the general character of the formations in the Coast Ranges. This becomes of the greatest value when there is taken into consideration the scarcity of fossils and the rare occurrence of distinct contacts. The jasper has until recently been considered a metamorphic rock. In a paper read before the Geological Society last August, the view was advanced

¹ American Geologist, Vol. IX., 153-166.

² American Geologist, Vol. XI., 69-84. Bull. Geol. Soc. Am., Vol. VI., 71-102.

by the writer that the jasper is not metamorphic, but that it is formed to a considerable extent of the remains of siliceous organisms of the radiolarian type. This opinion was based on the study of a number of thin sections of the rock from widely separated portions of the Coast Ranges. F. Leslie Ransome has recently announced the discovery of the first radiolarian remains found in a state sufficiently well preserved for description. Many specimens of jasper were collected on the recent trip through Monterey and San Louis Obispo counties, and nearly all showed the radiolaria visible to the unaided eye. The best were obtained from a large outcrop of greenish white jasper on the Eagle Ranch, six miles northwest of Santa Margarita. A microscopic study shows that portions of this rock are made up almost wholly of radiolaria which are in a better state of preservation than any previously found, fifteen or more specific forms being made out. The jasper beds vary from a few feet to more than a hundred feet in thickness, and exhibit more or less distinctly a banded structure. The bands are often contorted so as to present a beautiful wavy appearance. The accompanying illustration is from a photograph of a magnificent outcrop on the coast of Monterey near the mouth of the Sur River. It illustrates both the banding and the wavy structure. Comparatively uniform conditions must have existed over the whole of the area covered by the Golden Gate series, where the rocks were being deposited, for the jasper beds are found almost everywhere that the rocks of this series are exposed. Similar conditions did not obtain during the Cretaceous, for jasper is not known in any beds of that age on the Pacific coast. The series of beds of which the jasper forms such a striking feature undoubtedly possess a great thickness, but they have not yet been studied sufficiently in regions where the greatest development occurs to admit of any definite statement of their thickness. It is not probable that the jasper is confined to one horizon in the series, and the strata have been so sharply folded, shattered, and crushed together by orographic movements, as well as by the intrusion of numerous eruptives, that its study is accompanied by uncommon difficulties. Sandstone

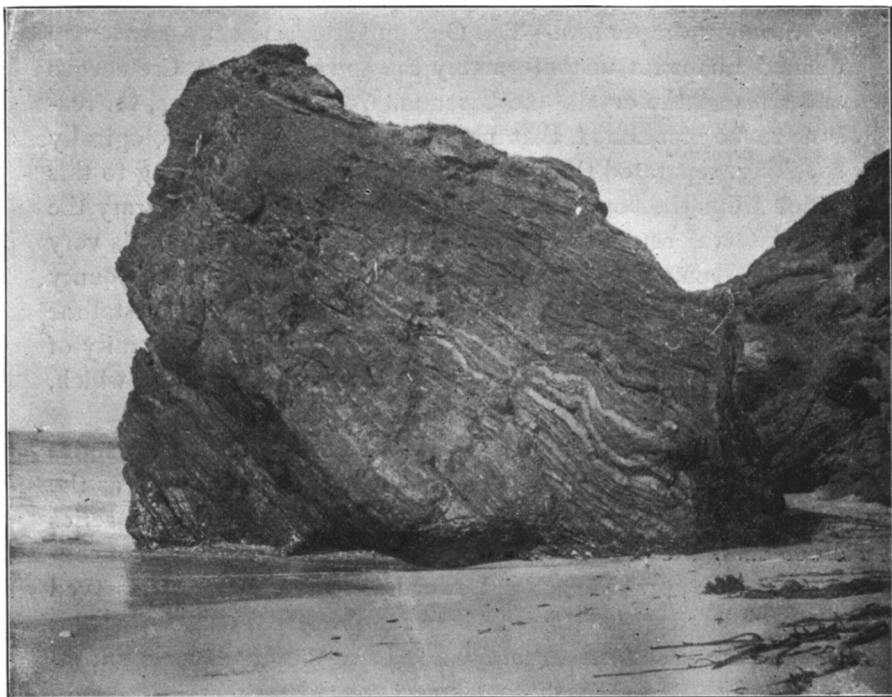


FIG. 1. Banded Jasper of the Golden Gate series, coast of Monterey county, California, near the mouth of the Sur River.

forms the larger part of the series wherever the writer has investigated it. The sandstone strata are often thick-bedded, which fact, taken together with the distortion undergone makes it very difficult to determine the bedding in small outcrops. Shale or slate occurs in subordinate amount, as thin layers between the sandstone strata, or more rarely in thick beds as in some portions of the Santa Lucia Mountains and the northern Coast Ranges.

Stratigraphic position.—The Golden Gate series as previously defined underlies unconformably the lowest known Cretaceous and rests on the crystalline basement rocks. It seems, for reasons to be mentioned, that no great lapse of time, geologically speaking, separated the deposition of the beds belonging to this series from the lowest Knoxville beds, but on the contrary the time interval separating it from the crystalline basement is very great. At numerous points along the coast of Monterey county this Golden Gate series rests on the granite and crystalline schists. For a distance of three or four miles in the vicinity of Slate's Springs it terminates below with a conglomerate which, on Hot Spring Creek, is 1000 feet thick.

The question of the relation between the Golden Gate series and the Knoxville is the all-important one. As far south as the fortieth parallel Mr. Diller has proved the existence of a series older than the Knoxville and separated from it by a nonconformity. Four miles east of Lower Lake the writer has observed an undoubted nonconformity between the *Aucella*-bearing shales and the older series. About Clear Lake the Chico rests unconformably on upturned masses of sandstone, jasper, and slate. In the Cañon of Capel Creek, Napa county, there are good evidences of a nonconformity between the Knoxville and an older series. In the Coast Range south of San Francisco the writer has observed the Chico at many points resting unconformably on a series of rocks lithologically very similar to that underlying the Knoxville farther north. The recent trip through the Santa Lucia Range resulted in the discovery of several distinct contacts between the *Aucella*-bearing Knoxville shales and an under-

lying series of jasper and sandstone. The most northerly known occurrence of the Knoxville beds in the Santa Lucia Range is on Pine Mountain opposite the town of San Simeon. The Knoxville beds here outcrop on the very summit of the range, being partly capped by liparite. They have an exposure of at least two miles from northwest to southeast and a width of a mile. The lower slopes of the mountain surrounding the beds consist of jasper, sandstone and dark, fine-grained eruptives. A section exposed along the grade of an old road crossing the mountain makes it very evident that the Knoxville overlies these rocks unconformably, but no good contacts were found there owing to the enormous amount of débris. On the southern slope the Knoxville beds are well exposed, dipping northerly at a gentle angle. To the east they are replaced by a ridge formed of hard sandstone and jasper, and in a little gulch eroded between these two formations, their relation to each other is distinctly shown. At one point the bottom and east side of the gulch consists of gray sandstone with thin, irregular layers of shale having a vertical dip and a north and south strike. On the west side the Knoxville shales, *Aucella*-bearing a few hundred feet above, appear in contact with the sandstone, dipping west at an angle of 40° . A short distance further up the gulch the Knoxville shales extend up to and overlie the gray sandstone with as marked a discordance in dip as that first noted. Less than one hundred feet away green jasper is interstratified with the sandstone.

Another area of the Knoxville beds occurs in the same range, north of the town of San Luis Obispo. The beds form much of the mountainous area extending from the railroad tunnel northwest for about fifteen miles. On the southwest these beds rest against a great serpentine ridge which forms one of the crests of the range. On the northeast they are underlaid by the sandstone and jasper of the Golden Gate series. At many points about the heads of Toro and Morro Creeks the Knoxville appears to have no great thickness, for it flanks the little hills and ridges of the Golden Gate series which project through it in the most

irregular manner. Numerous points were found where the contact was obscured by only a few feet of débris. The *Aucella* appeared widely distributed in the shales and sandstone, but its stratigraphic position could not be determined because of the complexity of the structure. On the summit of the range between Morro Creek and the Arroyo Atascadero a narrow arm of the Knoxville shales and sandstone is folded in vertically between ridges of the older series. The contact is plainly shown in the bed of a dry arroyo. Specimens of *Aucella* were obtained from a coarse sandstone blending into a conglomerate at a point which was apparently the lowest portion of the beds.

The Golden Gate series projects through the Knoxville in many places near the Eagle Ranch House. The former consists of jasper, sandstone and shale with large bodies of greenish, fine-grained eruptives. Absolute contacts showing an unconformable superposition of the Knoxville are rare because of the amount of soil everywhere present. More than a score of instances were noted where the contact between the two formations was hidden by only a slight amount of soil so that a few hours' work with a shovel would uncover it. The contacts already found, however, showing an unconformity, taken together with those where it is probable though not distinctly shown, and which would be accepted without hesitation by one thoroughly familiar with the two formations, establish on stratigraphic grounds the existence of an uncrystalline series below the Knoxville.

Faunal relations.—Fossil remains characteristic of a definite horizon have not yet been found in the Golden Gate series. This is a most remarkable fact when there is taken into consideration its extent, and the amount of study which has been given to it. The first fossil found in rocks which the writer would refer to this series is the *Inoceramus elliotti*, Gabb, from Alcatraz Island, obtained by Whitney. This was considered at the time as positive proof of the Cretaceous age of the San Francisco sandstone. In the summer of 1892 the writer obtained several poorly preserved specimens of *Inoceramus* from a bed of black

slate at Slate's Springs on the coast of Monterey county. This locality was revisited the past fall in company with Mr. Anderson, and a collection made embracing five species of lamelli-branches and a number of plants. The former though somewhat crushed were well enough preserved for generic determination. Unfortunately they proved to be very puzzling and threw but little light on the question at issue. They were submitted to Mr. T. W. Stanton for determination and the following description is given by him: "The collection includes a large species of *Inoceramus*, a large *Homomya* (?), *Macrodon*, *Leda* and *Rhynchonella*, none of which can now be referred to described species. The *Inoceramus* seems to me the most important form in determining the age, as it is confined to the Mesozoic, and a species of this size and type is probably not older than the Jurassic and might be Cretaceous. *Inoceramus quatsinoensis*, Whiteaves, from the *Aucella*-bearing Cretaceous beds of Vancouver is a similar species. Taking this in connection with the statements of yourself and Mr. Anderson concerning the field and stratigraphic relations of the beds, the most reasonable inference would seem to be Jurassic. The other fossils apparently do not conflict with this reference."

In the absence of confirmatory evidence the *Inoceramus* from Alcatraz Island cannot be accepted as proof of the Cretaceous age of the strata there, and it is very probable that the horizon represented is the same or nearly the same as that of the Slate's Springs beds.

The recent discovery of radiolaria in the jasper of the Golden Gate series not only adds greatly to the interest of these rocks but also may aid in the solution of the age problem. Those found by Mr. Ransome and Professor Lawson, and submitted to Mr. Hinde for examination, are, according to his description, forms similar to those occurring in the jasper of the Upper Jurassic and Lower Cretaceous of Europe. A part of the European beds containing the radiolaria are believed to belong to the upper Jurassic, while opinion is divided as to the exact horizon of the others. The specimens obtained by the writer

from the Eagle Ranch resemble those from Angel Island, but the number of species is greater and the state of preservation better in many cases. In Vol. XXXI. of the *Palæontographica* Rüst gives a plate on which are figured a group of radiolaria from the red jasper of west Switzerland which belongs to the upper division of the Jurassic. A comparison of the figures on this plate with those in a slide from the Eagle Ranch shows a remarkable similarity of the forms. At least five forms in the slide are closely allied to those on the plate.

It will be seen that as far as faunal evidence is concerned the question cannot yet be considered as satisfactorily settled. This much can be said, however, that the fossil remains found on the one hand in the jasper in different portions of the series, and in the slates near its base on the coast of Monterey, indicate with a strong degree of probability that the series as a whole is not older than the Jurassic and may belong to its upper division. Some of the forms, especially that of the *Inoceramus*, are very closely allied to known Cretaceous species, so that if palæontology alone had to be relied upon the question is at present a puzzling one. When, however, in addition to the faunal evidence, there is taken into account the fact of the unconformable position of the series beneath the Knoxville, the writer believes that its horizon can be stated with a considerable degree of certainty as Upper Jurassic. It may be best to add here that the application of the term Jurassic to this series is based on the fact that the Knoxville is at present considered by palæontologists as belonging to the Lowest Cretaceous. The writer does not wish to be understood as contending in this or in other articles previously published for a Jurassic series *per se*, but for the recognition of the existence of an uncrystalline series underlying the base of the Knoxville.

Stratigraphic position of the beds at Slate's Springs.—Lithologically the strata are entirely different from any portion of the known Cretaceous on the Pacific coast. They are considerably metamorphosed and in places extremely distorted and bronke. They stand nearly vertical and consist of alternating layers of

sandstone and slate. They are followed downward by a thick conglomerate, while other layers of similar conglomerate are exposed in the edge of the ocean. The whole series has an exposed thickness of 1500 feet from the base to the ocean cliffs, and extends an unknown distance beneath the sea. The slates and sandstones form a narrow belt, at times almost cut out by bodies of eruptive origin, for a number of miles down the coast. They gradually widen out to form the great area of pre-Knoxville rocks of the Santa Lucia Mountains in southern Monterey and northern San Luis Obispo counties. Four miles south of Slate's Springs and north of Big Cañon bodies of jasperoid rocks are associated with the sandstone. On the ridge south of Big Cañon are a number of outcrops of red jasper. At the mouth of Mill Creek is another body of jasper. Near the mouth of Vicente Creek slates outcrop along the cliffs facing the ocean, bearing the closest resemblance to those at Slate's Springs. A short distance south of Vicente Creek there are large outcrops of a banded red jasper. The Slate's Springs beds thus appear to be both stratigraphically and lithologically continuous with the Golden Gate series which on Pine Mountain underlies the Knoxville beds unconformably. Mr. Anderson, who has given considerable study to the Cretaceous of Oregon and northern California, agrees entirely with the writer with regard to the strongly marked lithological contrast between the strata at Slate's Springs and the Cretaceous, and their resemblance to portions of the Auriferous Slate series.

THE TIME INTERVAL BETWEEN THE KNOXVILLE AND THE
GOLDEN GATE SERIES.

The great deformation exhibited by the Golden Gate series, its much higher degree of solidification and partial metamorphism, the numerous included bodies of eruptives formed prior to the deposition of the Knoxville, and the marked nonconformity between it and the Knoxville, all point to a time interval of considerable extent, during which there were violent disturbances terminating in its elevation and erosion. This interval may

represent a portion of the uppermost Jurassic or possibly the very base of the Cretaceous. Dr. White has represented graphically the position of the different divisions of the California Cretaceous in his Correlation papers. According to this the extreme basal portion of the Cretaceous is absent. The more recent work of Messrs. Diller and Stanton, which has been carried out with the greatest care, places the Knoxville at the base of the Cretaceous. This places the Golden Gate series in the Jurassic, and probably at a horizon which corresponds very closely with that represented by the Mariposa beds. Although the fauna at present known from the Golden Gate series is indeterminate in its time relations, as far as the Jurassic or Cretaceous is concerned, the pronounced nonconformity between it and the Knoxville must be taken into account. The interval necessary for the deformation, metamorphism and erosion of the lower series must have been considerable, and is to be correlated with that found by Mr. Diller to exist between the Upper Jurassic beds of northern and central California, and the Shasta-Chico series of the Sacramento Valley. The increasing mass of evidence is in favor of the views of Mr. Diller concerning the synchronism of the great revolution in the Sierras and the Klamath Mountains, which he holds took place near the termination of the Jurassic. Accepting this as true, as the writer has stated in former publications, a demonstration of the extension of this nonconformity southward also proves that the underlying rocks are at least as old as the Jurassic.

THE NONCONFORMITY BETWEEN THE CHICO AND KNOXVILLE IN
THE SOUTHERN COAST RANGES.

In several papers the writer has expressed the opinion that there is evidence at many points in the Coast Ranges of the existence of a nonconformity between the Chico and Knoxville beds. This nonconformity is supposed to be due in part to a post-Knoxville elevation when numerous bodies of peridotitic eruptives were formed. As far as is known the Horsetown beds are absent from the Coast Ranges south of San Francisco. Until recently the Upper and Lower Cretaceous had not been

found together in that portion of the state, and their relation to each other was more or less a matter of inference. The contact which has just been found is on the Eagle Ranch in the Santa Lucia Range. The central portion of the range is there formed of Knoxville shales and sandstone carrying *Aucella*, the total width exposed being about three miles. The Knoxville is bordered on the west by a great dike of serpentine, while on the east a nearly hidden axis belonging to the Golden Gate series projects through it in numerous places. The Knoxville presents a very much disturbed condition, partly due to the dikes of serpentine. The Chico, consisting almost wholly of heavy-bedded sandstone, rises on the eastern slope, overlapping the Knoxville shales and capping portions of the first line of hills. It has not undergone the same amount of disturbance as the Knoxville and is nowhere folded in with it, appearing rather as a thin capping on an irregularly eroded surface. Fossils were sought for a long time in the sandstone without any result. Finally a number of poorly preserved specimens were obtained from the summit of a hill about one mile south of the Ranch House. The following is the list: *Baculites chicoensis*, Trask. *Trigonia evansana* (?), Meek. *Pectunculus veatchi*, Gabb, *Cucullaea sp.*, *Pentacrinus sp.* In a small ravine near the spot where the fossils were obtained there is a contact between the sandstone and the dark shales. This ravine extends up the west side of the hill making a slight depression nearly to its summit. The northern portion of the hill is capped with a thin layer of the Chico sandstone, dipping south at an angle of 30°. The sandstone extends to the bed of the ravine and is there exposed resting on the shales. The latter are well shown, not only underneath the sandstone but also on the slope of the hill south into which the dip of the sandstones would carry them. The sandstone has a very regular bedding while the shale underneath is so broken that the stratification is not distinctly visible. The spot was examined particularly with reference to the possibility of the phenomena being due to faulting, but no evidence of it could be discovered. Fossils were not found in the Knox-

ville near the sandstone, but at the base of the hill one-half mile distant, in strata which could be traced by continuous outcrop to the contact. On the north fork of the Atascadero, three miles northwest of this locality, is an *Aucella*-bearing stratum folded in between the older rocks. About 500 feet north of the vertical Knoxville shales is a hill capped with a body of Chico sandstone with only slightly inclined bedding planes. This hill lies directly in the strike of the shales, and although no contact is visible there can be no doubt of an unconformity.

THE RELATION OF THE SERPENTINE TO THE CHICO-KNOXVILLE
UNCONFORMITY.

The absence of the Horsetown beds and the presence of numerous large bodies of serpentine favor the supposition of a break between the upper and lower divisions of the Cretaceous. Serpentine occurs intruding the Knoxville and older rocks at many points along the Santa Lucia Range. It seemed probable that such was the case on Pine Mountain although no good exposures were found. Near the Old Padre mine, west of Santa Margarita, the Knoxville shales in contact with the serpentine are considerably metamorphosed. On the Eagle Ranch a dike of serpentine has been cut on one of the grades, showing its intrusion in the Knoxville shales. The writer has never seen serpentine intruded in the Chico in any portion of the Coast Ranges, and all indications point to its formation during the interval between the deposition of the Knoxville beds and the Chico. In the southern Coast Ranges at least, the disturbance must have caused an elevation of the Knoxville, so that during the period represented by the deposition of the Horsetown beds in northern California, the former must have been above water and undergoing erosion.

THE NON-CONFORMITY BETWEEN THE MIOCENE AND THE CHICO-
TEJON SERIES.

An examination of geological literature relating to the Coast Ranges shows that the Miocene has generally been held to have been deposited conformably on the Chico-Tejon series. This

question had not been studied in the southern Coast Ranges prior to the work done there by the writer. In that field numerous occurrences were noted where the Miocene unconformable overlaid the Chico, or Tejon, as the case might be. The non conformity was pronounced wherever contacts could be found, for a distance of 200 miles, through the counties of Ventura, Santa Barbara, San Luis Obispo, and Monterey. Topographically the southern portion of this region is very rugged and difficult of exploration. The deep cañons and brushy mountains rising 5000-7000 feet make access to it almost impossible except along the scattered trails. Geologically portions are quite complex but there are large areas where the Cretaceous, Lower and Middle Tertiary are the only horizons represented. The assemblage of strata belonging to the Upper Cretaceous and the Lower Tertiary, known in geological literature as the Chico-Tejon series, is particularly prominent in northern Ventura and southern Santa Barbara counties. The Miocene not only forms complete mountain ranges, as for example, the Santa Ynez, but also appears as fringes along the Chico-Tejon elevations and in detached areas almost on their very summits. Beginning in northern Ventura county the various localities will be described where the relation of the Miocene to the Chico and Tejon was observed. Pine Mountain in northern Ventura county extends in an east and west direction between Cuyamas River on the north and the Sespe on the south. It forms the northern portion of a great thickness of dark shales and sandstones which have a width, north and south across their line of strike, of nearly twelve miles. Fossils were collected from two localities on this section, but so complex is the structure that the exact position in the series was not determined, although it seems that they are from the upper portion. On the northern slope of Pine Mountain the following fossils were collected: *Meretrix horni*, Gabb; *Fusus remondi*, Gabb; *Neverita globosa*, Gabb; *Dentalium pusillum*, Gabb; *Turris varicostata* (?), Gabb; *Actæonella oviformis* (?), Gabb; *Turritella sp.* The horizon indicated is the Tejon. Near the head of the Matilija Cañon, about eight miles southward, there was collected the

following Tejon forms: *Crassatella grandis*, Gabb; *Meretrix horni*, Gabb; *Cardium sp.*; *Fusus martinez*, Gabb; *Dentalium cooperi*. The Sespe in its upper course has eroded a broad longitudinal valley in the center of this formation. North of the stream on the southern slope of Pine Mountain is a body of heavy-bedded light yellow sandstone, dipping north generally at a small angle. Where the Matillija trail crosses it there were found numerous specimens of *Astrodapsis whitneyi*, Remond; fragments of *Ostrea titan*, Con., and *Pecten discus*, Con. Four miles down the cañon Dr. Bowers¹ has collected twenty-five Miocene species from the same sandstone. Although the actual contact was not observed, there can be no doubt as to the unconformity. The Tejon and possibly Chico strata below being steeply inclined and much broken, especially south of the Sespe, while the Miocene sandstone dips very regularly to the north into the Tejon, forming the summit and north slope of Pine Mountain. Near the mouth of Santa Barbara cañon there is a series of sandstones, gypsum-bearing clays, and limestones resting unconformably against dark thin-bedded sandstones and shales of undoubted Cretaceous age, although no fossils were found at this point. South of the Perkin's Ranch on the slopes of the Cuyamas Range are numerous areas of light yellow heavy-bedded sandstones resting on or against dark sandstones and shales. Specimens of a Miocene *Pecten* and *Ostrea* occur in the upper beds at different points. The following Chico fossils were found in the deep cañon of the Sisquoc, between the Cuyamas Range and the San Rafael Mountains: *Inoceramus, sp.*; *Meekia sella*, Gabb; *Pectunculus veatchi*, Gabb; *Cinulia obliqua*, Gabb; *Baculites chicoensis*, Trask; *Cylichna costata*, Gabb; *Tellina ashburneri*, Gabb; *Dentalium stramineum*, Gabb, and an unknown crustacean. The strata consisting of dark shales and thin-bedded sandstones are steeply tilted and much broken. Stratigraphically they seem to belong with the lowest beds in Santa Barbara Cañon. The uppermost beds at the head of the latter cañon occupy the highest position in a great synclinal fold, appearing to be a continuation of the Tejon on Pine Mountain. South of the Sisquoc,

¹ Report Cal. State Mining Bureau, p. 763.

capping the high mountains between it and the Manzana River, is a large area of light yellow sandstone, apparently not greatly disturbed. Continuing up the Sisquoc these sandstones were finally observed outcropping on the bank in direct contact with the Cretaceous. The discordance in dip of the two formations is about 15° . There does not seem to be any doubt about the reference of the sandstones to the Miocene, as they correspond exactly to the known Miocene only a short distance to the north. In the lower end of the Cuyamas valley are horizontal strata of incoherent sandstones bearing *Ostrea titan* and a species of *Pecten*, while only a short distance below are steeply inclined conglomerates and sandstones referable to the Chico.

In a small tributary cañon of the Santa Ynez River, below the old Mission, is a contact between a body of dark shales, closely simulating the Knoxville, and light yellow sandstone. The sandstone rests on the shales with a discordance in dip of 20° . In the shales no fossils were found, but in the sandstone two species were obtained: *Ostrea panzana* (?) Con., and *Pecten pabloensis* (?) Con. That portion of the Santa Lucia Range lying in southern San Luis Obispo county consists largely of heavy-bedded sandstones and conglomerates, which according to our present knowledge are wholly referable to the Chico. Near the head of the Santa Margarita Valley specimens of *Trigonia evansana*, Gabb, and *Axinea veatchi*, Gabb, were obtained from the sandstone. Five miles farther north several specimens of *Venus lenticularis*, Gabb, were found in a nodular mass of limestone in the same sandstones.

An excellent section of the Bituminous Slate series (Miocene) is shown for many miles along the Arroyo Grande which has its source in the Santa Lucia Range. Near its head in the vicinity of Music are extensive beds of sandstone carrying *Ostrea titan*, Con., and *Astrodapsis whitneyi*, Remond. Fully 2000 feet below this sandstone in the same series of rocks is a considerable thickness of soft argillaceous sandstone containing the following Miocene species: *Pectunculus patulus*, Con., *Leda cælata*, Hds., and *Arca microdonta*, Con. Between 200 and 300 feet below

these fossiliferous beds the Miocene terminates in a soft, white sandstone. This rock rests against nearly vertical beds of hard sandstone and shale which without much doubt are referable to the Chico, as they can be traced by continuous outcrop to localities where fossils of that age were found.

A narrow belt of Miocene shales extends diagonally across the Santa Lucia Range from a point west of Templeton to the head of Santa Rosa Creek. On the north fork of the Arroyo Atascadero this shale is filled with fish remains and the mollusk, *Pecten peckhami*, Gabb. The shales overlie rocks of the Golden Gate series and dip nearly vertically. Directly in line of their strike rises a hill of Chico sandstone, the bedding of which is nearly level. The Miocene can be traced by outcrop to within a few feet of the Chico; it was evidently deposited on the eroded surface of both the Golden Gate series and the Chico. The same white shales occur on the Eagle Ranch about three miles southeast of this point. There they dip about 30° southwestward apparently resting on the yellow Chico sandstones whose outcrop was obtained within 150 feet of the shales. The sandstone shows at many places a uniform dip of 20° to 30° to the northeast. West of the white shales is a hill of jasper partly capped by the Chico sandstone. The dip of the shales at the base of the hill is such that if extended they would pass beneath the two older formations. All the phenomena shown here point to the deposition of the Miocene on the eroded surface of the Chico.

CONCLUSION.

The correct determination of the age of the Golden Gate series is one of the most important questions in Coast Range geology. The accumulating evidences are strongly in favor of the view of its Upper Jurassic age. There can no longer be any doubt as to the unconformable position of the series beneath the Knoxville, and the fauna indicates that it is not older than the Jurassic.

If future detailed examinations should prove that the Horse-town beds are absent from the southern Coast Ranges, there

must be postulated a considerable period during the middle of the Cretaceous in which that region was elevated and undergoing erosion.

The Chico-Tejon has a thickness of at least 20,000 feet in several places. We have no knowledge at present of a stratigraphic break in the series, but the direct superposition of the Miocene on the Chico in many localities lends some degree of probability to the view that a break exists.

The Miocene exposed on the Arroyo Grande has a thickness of from 5000 to 8000 feet. The succession of strata from the top downward is as follows: (1) Bituminous slate, (2) Sandstone carrying *Ostrea titan*, (3) Bituminous slate and argillaceous sandstone.

In the vicinity of the Eagle Ranch there is one of the most interesting associations of strata of different age to be found in the Coast Ranges. Four formations are present from all of which fossils were obtained: The Miocene, Chico, Knoxville and Golden Gate series, each being separated from the others by a nonconformity.

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